

**TRANSMITTAL OF APPEAL BRIEF**Docket No.  
77897-US1

In re Application of: M Ashraf Imam et al.

Application No.  
08/845,897-Conf. #8846Filing Date  
April 28, 1997Examiner  
H. VoGroup Art Unit  
1771

Invention: POROUS METAL/ORGANIC POLYMERIC COMPOSITES

**TO THE COMMISSIONER OF PATENTS:**Transmitted herewith is the Appeal Brief in this application, with respect to the Notice of Appeal  
filed: October 2, 2007 .The fee for filing this Appeal Brief is \$ 510.00 .☒ Large Entity ☐ Small Entity☒ A petition for extension of time is also enclosed.The fee for the extension of time is \$ 120.00 .☐ A check in the amount of \_\_\_\_\_ is enclosed.☒ Charge the amount of the fee to Deposit Account No. 50-0281 .  
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**IN THE UNITED STATES PATENT AND TRADEMARK OFFICE**

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In re Patent Application of:  
M Ashraf Imam et al.

Application No.: 08/845,897

Confirmation No.: 8846

Filed: April 28, 1997

Art Unit: 1771

For: POROUS METAL/ORGANIC POLYMERIC  
COMPOSITES

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Examiner: H. Vo

**APPEAL BRIEF**

MS Appeal Brief - Patents  
Commissioner for Patents  
P.O. Box 1450  
Alexandria, VA 22313-1450

As required under § 41.37(a), this brief is filed more than two months after the Notice of Appeal filed in this case on October 2, 2007, and is in furtherance of said Notice of Appeal. A Petition for Extension is attached.

The fees required under § 41.20(b)(2) are dealt with in the accompanying TRANSMITTAL OF APPEAL BRIEF.

This brief contains items under the following headings as required by 37 C.F.R. § 41.37 and M.P.E.P. § 1205.2:

- |      |   |
|------|---|
| I.   | Real Party In Interest                        |
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I. REAL PARTY IN INTEREST

The real party in interest for this appeal is:

The Government of the United States of America, as represented by the Secretary of the Navy

II. RELATED APPEALS AND INTERFERENCES

This is the second appeal of this application. In the first appeal (2005-2658) rejections over Reitz (US 4,759,000) were reversed and rejections over Tsang et al. (4,605,595) were affirmed on 09/28/2005. The claims have subsequently been amended to overcome the rejections over Tsang. A copy of the prior decision on appeal is included in the Related Proceedings Appendix.

III. STATUS OF CLAIMS

A. Total Number of Claims in Application

There are 28 claims pending in application.

B. Current Status of Claims

1. Claims canceled: none
2. Claims withdrawn from consideration but not canceled: 5, 6, 8-10, 12-16
3. Claims pending: 1-28
4. Claims allowed: none
5. Claims rejected: 1-4, 7, 11, 17-28

C. Claims on Appeal

The claims on appeal are claims 1-4, 7, 11, 17-28

#### IV. STATUS OF AMENDMENTS

Applicant did not file an Amendment after Final Rejection.

#### V. SUMMARY OF CLAIMED SUBJECT MATTER

Independent claim 1 recites an acoustically damping composite article (page 3, lines 4-5) comprising: a non-elastomeric polymeric matrix (page 9, lines 14-16 and page 12, line 1) having therein a metal foam (page 5, lines 12-13), said metal foam having an open cell structure (page 5, line 14), said metal foam being impregnated with said polymeric matrix (page 7, line 24-page 8, line 6) and so as to completely penetrate said open cell structure of said foam and fill the cells thereof (page 8, lines 17-20); and optionally, one or more additional components selected from a catalyst, a curing agent, a curing additive, and a release agent (page 8, lines 1-3 and page 10, line 17), wherein the article comprises from about 60 to about 95 vol.% of the polymeric matrix (page 7, line 7).

Independent claim 21 recites an acoustically damping composite article (page 3, lines 4-5) comprising: a polymeric matrix (page 12, line 1) having therein a metal foam (page 5, lines 12-13), said metal foam being impregnated with said polymeric matrix (page 7, line 24-page 8, line 6) so as to completely penetrate said open cell structure of said foam and fill the cells thereof (page 8, lines 17-20), said metal foam thickness no smaller than 3 times the average diameter of said cells (page 11, lines 3-6); and optionally, one or more additional components selected from a catalyst, a curing agent, a curing additive, and a release agent (page 8, lines 1-3 and page 10, line 17), wherein the article comprises from about 60 to about 95 vol.% of the polymeric matrix (page 7, line 7).

Independent claim 22 recites a method of forming a composite comprising the steps of: impregnating a metal foam (page 7, line 24-page 8, line 6), said metal foam having an open cell structure (page 8, lines 17-20), with a resin component (page 7, line 24-page 8, line 6) and optionally, one or more additional components selected from a catalyst, a curing agent, a curing additive, and a release agent (page 8, lines 1-3 and page 10, line 17), so as to completely penetrate said open cell structure of said foam and fill the open cells of said metal foam with said resin component (page 8, lines 17-20); and converting said resin component, within said cells, to a bulk solid, non-elastomeric polymerized resin (page 8, lines 9-14 and page 9, lines 13-16), thus forming a

composite comprising: a matrix of said non-elastomeric polymerized resin (page 5, lines 12-15 and page 9, lines 13-16), said matrix having therein said metal foam (page 5, lines 12-13) and the optional additional component (page 8, lines 1-3 and page 10, line 17), wherein the composite comprises from about 60 to about 95 vol.% of the matrix (page 7, line 7).

There are no means plus function limitations in any appealed claim.

## VI. GROUNDS OF REJECTION TO BE REVIEWED ON APPEAL

- A. Claims 1-4, 7, 11, 19, 22, 23, and 25-28 stand rejected under 35 U.S.C § 102(b) as being allegedly anticipated by Tsang et al. (US Patent No. 4,605,595).
- B. Claims 17, 18, 20, 21, and 24 stand rejected under 35 U.S.C § 103(a) as being allegedly unpatentable over Tsang.
- C. Claims 1-4, 7, 11, and 17-28 stand rejected under 35 U.S.C § 103(a) as being allegedly unpatentable over Yang et al. (US Patent No. 5,516,592) in view of Akiyama (US Patent No. 4,713,277).

## VII. ARGUMENT

- A. Claims 1-4, 7, 11, 19, 22, 23, and 25-28 recite subject matter that is not anticipated under 35 U.S.C § 102(b) by Tsang.

### 1) Claims 1-4, 7, 11, 19, 22, 23, and 25-28

Tsang discloses a method of manufacturing a friction article. The method involves a filler, a friction modifier, and a reinforcing fiber carried in a liquid binder drawn into the pores of an open metal foam structure until a desired density is obtained (col. 1, lines 53-59).

In order to make a *prima facie* case of anticipation, the reference must disclose each limitation of the claim. *Verdegaal Bros. v. Union Oil Co. of California*, 2 U.S.P.Q.2d 1051, 1053, 814 F.2d 628, 631 (Fed. Cir. 1987); MPEP 2131. Among other deficiencies, the reference does not

disclose the limitation in claims 1 (claims 2-4, 7, 11, 19, 23, and 26 dependent thereon), 21 (claim 27 dependent thereon) and 22 (claims 25 and 28 dependent thereon) that the article comprises from about 60 to about 95 vol.% of the polymeric matrix. This limitation was added to the claims subsequent to the Board's prior affirmance of rejections over Tsang. Tsang discloses the weight percentages of the ingredients (Fig. 2) but not their densities. Given that the highest disclosed weight percentage of binder is 40 wt.% (col. 3, line 26) and the high amounts of fillers used, 60 vol.% binder is not disclosed.

The fact that this limitation is not disclosed in Tsang was admitted to by the Examiner, stating "Tsang does not disclose the composite material comprising from 60-95% by volume of the polymeric matrix" (Office action of 05/30/2006, page 2, lines 2-4). After withdrawing the rejection and asserting a new obviousness rejection over Tsang in view of another reference (05/30/2006), followed on 03/21/2007 by withdrawing the obviousness rejection and, despite the lack of any intervening amendments to the independent claims, reasserting the present rejection over Tsang alone, the Examiner now states that the claims do not preclude the polymeric matrix from having inorganic fillers and that therefore the slurry of Tsang reads on the claimed polymeric matrix (Office action of 08/10/2007, page 6, lines 20-22).

Although claims 1-4, 7, 11, 19, 22, and 26-28 do not preclude the presence of inorganic fillers, any such filler is not a part of the volume fraction of polymeric matrix. It is known in the field of composites that the matrix is a continuous phase surrounding the other components (e.g., fillers) of the composite. In attached article "Composite material" *McGraw-Hill Encyclopedia of Science and Technology* (9<sup>th</sup> ed. 2002)<sup>1</sup>, it is stated that major constituents of composites are fibers, particles, laminae or layers, flakes, fillers, and matrices (paragraph bridging pages 508-509). The matrix is a separate constituent from any filler, and the filler is not a part of the matrix. The recited vol% of the polymeric matrix in claim 1 refers to the amount of the polymer only. Further, even though a claim is open by use of "comprising" in the preamble, it does not mean that each of the recited elements is open to anything that is not specifically excluded from the element. To read

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<sup>1</sup> In the advisory action of 12/12/2007, the Examiner stated that this evidence was entered but not considered because there was no showing of good and sufficient reasons why it is necessary and not earlier presented. However, the evidence is necessary to rebut the Examiner's argument that the claimed vol.% of polymeric matrix would include any filler. This argument was first presented in the final rejection of 08/10/2007, so there was no reason to present the evidence before the final rejection.

open claims in the manner suggested by the Examiner would render the elements of any such claim to be meaningless. In the present case, the Examiner's interpretation could result in "60 vol% polymeric matrix" reading on a reference showing only 0.001 vol% polymeric matrix and 59.999 vol% of anything else.

## 2) Claims 23 and 25

These claims recite the phrase "consists of" in the preamble. This phrase does exclude composites containing the filler, friction modifier, and reinforcing fiber of Tsang. The Examiner stated that the catalyst, curing agent, curing additive, or release agent recited in these claims "read pretty much on anything which could include a filler, so claims 23 and 25 are essentially as open as claim 1" (page 7, lines 4-5).

There is no explanation as to how catalyst, curing agent, curing additive, or release agent encompasses "anything." However, the Examiner's own statement admits that it actually does not read on everything. If it were to read on "pretty much anything," (emphasis added) then there must be something it does not read on. For example, the filler of Tsang is not a catalyst and has nothing to do with curing or releasing. Thus, composites of Tsang containing the filler are excluded from the scope of these claims.

## 3) Claims 26-28

These claims recite a more specific range, about 92 to about 94 vol.%, that is also not disclosed in Tsang.

B. Claims 17, 18, 20, 21, and 24 recite subject matter that is not unpatentable under 35 U.S.C § 103(a) over Tsang.

An obviousness rejection over Tsang was also asserted in the Office action of 01/06/2006, withdrawn on 05/30/2006, and now reasserted on 03/21/2007.

## 1) Claims 17, 18, 20, 21, and 24

The rejection notes a number of differences between the claimed subject matter and Tsang. A difference that is not addressed is the previously admitted difference that “Tsang does not disclose the composite material comprising from 60-95% by volume of the polymeric matrix” (Office action of 05/30/2006, page 2, lines 2-4), as recited in claims 1 (claims 17, 18, and 20 dependent thereon) and 21 (claim 24 dependent thereon). (As explained above, this limitation is not disclosed in Tsang, despite the Examiner’s rationale for finding such a disclosure.) The rejection is deficient because no rationale is given why a person of ordinary skill in the art would modify Tsang in this way. Further, the Office action contains no indication as to the level of ordinary skill in the art that would be relevant to this modification, as required by *Graham v. John Deere Co.*, 148 U.S.P.Q. 459, 383 U.S. 1 (1966).

## 2) Claim 24

This claim recites a more specific range, about 92 to about 94 vol.%, that is also not disclosed in Tsang, nor is any rationale given why a person of ordinary skill in the art would make such a modification.

C. Claims 1-4, 7, 11, and 17-28 recite subject matter that is not unpatentable under 35 U.S.C § 103(a) over Yang in view of Akiyama.

## 1) Claims 1-4, 7, 11, and 17-28

Yang discloses impregnating a foamed aluminum alloy plate with a hardness-reinforcement composition containing an inorganic powder and a curable resin (Abstract). Akiyama discloses a foamed metal with no teaching of filling the pores (Abstract).

The arguments above regarding Tsang also generally apply to this rejection. As with Tsang, neither Yang nor Akiyama discloses the limitation in claims 1 (claims 2-4, 7, 11, 17-20, 23, and 26



dependent thereon), 21 (claims 24 and 27 dependent thereon), and 22 (claims 25 and 28 dependent thereon) that the article comprises from about 60 to about 95 vol.% of the polymeric matrix. The hardness-reinforcement composition of Yang contains both resin and inorganic powder, but the vol% of the polymeric matrix is not disclosed. Akiyama does not disclose any resin. The Examiner stated that the combination would comprise about 90 vol% of the reinforcing composition (page 5, lines 15-17). However, the reinforcing composition contains inorganic powder. The vol% of the resin alone is not disclosed. The Office action states no rationale for modifying the references with the claimed vol.% of polymeric matrix.

## 2) Claims 23-25

These claims recite the phrase “consists of” in the preamble. This phrase excludes composites containing the inorganic powder of Yang.

## 3) Claims 26-28

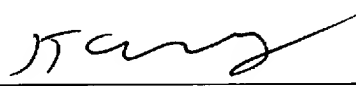
These claims recite a more specific range, about 92 to about 94 vol.%, that is also not disclosed in the references, nor is any rationale given why a person of ordinary skill in the art would make such a modification.

VIII. CLAIMS

A copy of the claims involved in the present appeal is attached hereto as the Claims Appendix. As indicated above, the claims include the amendments filed by Applicant on January 17, 2007, concurrent with a request for continued examination.

Dated: 12/21/2007

Respectfully submitted,

By 

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**CLAIMS APPENDIX**

**Claims Involved in the Appeal of Application Serial No. 08/845,897**

1. An acoustically damping composite article comprising:  
a non-elastomeric polymeric matrix having therein a metal foam, said metal foam having an open cell structure, said metal foam being impregnated with said polymeric matrix so as to completely penetrate said open cell structure of said foam and fill the cells thereof; and  
optionally, one or more additional components selected from a catalyst, a curing agent, a curing additive, and a release agent,  
wherein the article comprises from about 60 to about 95 vol.% of the polymeric matrix.
2. The composite article of claim 1, wherein said metal is selected from the group consisting of aluminum, aluminum base alloys, titanium, titanium base alloys, nickel, nickel base alloys, copper, copper base alloys, iron, iron base alloys, zinc, zinc base alloys, lead, lead base alloys, silver, silver base alloys, gold, gold base alloys, platinum, platinum base alloys, tantalum, and tantalum base alloys.
3. The composite article of claim 1, wherein said polymer is selected from the groups consisting of epoxies, acrylics, hardened silicones, polyurethanes, polyimides, polyvinyls, polycarbonates, hardened natural rubbers, hardened synthetic rubbers, phenolics, polyolefins, polyamides, polyesters, fluoropolymers, poly(phenylene ether ketones), poly(phenylene ether sulfones), poly(phenylene sulfides) and melamine-formaldehyde resins.
4. The composite article of claim 1, wherein said metal is an aluminum base alloy foam.

7. The composite article of claim 3, wherein said metal is an aluminum foam or an aluminum base alloy foam.
11. The composite article of claim 1, wherein said polymer is an epoxy.
17. The composite article of claim 1, wherein said cells have a locally uniform diameter.
18. The composite article of claim 1, wherein said metal foam has a gradation of pores sizes in at least one direction along the metal foam.
19. A composite article according to claim 1, wherein said composite article is in the form of a sheet.
20. A laminate comprising a stack of sheets according to claim 19 bonded together.
21. An acoustically damping composite article comprising:  
a polymeric matrix having therein a metal foam, said metal foam being impregnated with said polymeric matrix so as to completely penetrate said open cell structure of said foam and fill the cells thereof, said metal foam thickness no smaller than 3 times the average diameter of said cells; and  
optionally, one or more additional components selected from a catalyst, a curing agent, a curing additive, and a release agent,  
wherein the article comprises from about 60 to about 95 vol.% of the polymeric matrix.

22. A method of forming a composite comprising the steps of:  
impregnating a metal foam, said metal foam having an open cell structure, with a resin component and optionally, one or more additional components selected from a catalyst, a curing agent, a curing additive, and a release agent so as to completely penetrate said open cell structure of said foam and fill the open cells of said metal foam with said resin component; and  
converting said resin component, within said cells, to a bulk solid, non-elastomeric polymerized resin, thus forming a composite comprising:  
a matrix of said non-elastomeric polymerized resin, said matrix having therein said metal foam and the optional additional component,  
wherein the composite comprises from about 60 to about 95 vol.% of the matrix.
23. The composite article of claim 1, wherein the composite consists of the non-elastomeric polymeric matrix having therein a metal foam and optionally, one or more additional components selected from a catalyst, a curing agent, a curing additive, and a release agent.
24. The composite article of claim 21, wherein the composite consists of the non-elastomeric polymeric matrix having therein a metal foam and optionally, one or more additional components selected from a catalyst, a curing agent, a curing additive, and a release agent.
25. The method of claim 22, wherein the composite consists of the non-elastomeric polymeric matrix having therein a metal foam and optionally, one or more additional components selected from a catalyst, a curing agent, a curing additive, and a release agent.
26. The composite article of claim 1, wherein the article comprises from about 92 to about 94 vol.% of the polymeric matrix.
27. The composite article of claim 21, wherein the article comprises from about 92 to about 94 vol.% of the polymeric matrix.

28. The method of claim 22, wherein the composite comprises from about 92 to about 94 vol.% of the matrix.

**EVIDENCE APPENDIX**

A copy of evidence pursuant to §§ 1.130, 1.131, or 1.132 and/or evidence entered by or relied upon by the examiner that is relevant to this appeal is attached hereto.

“Composite material” *McGraw-Hill Encyclopedia of Science and Technology* (9<sup>th</sup> ed. 2002) (Filed on 10/02/2007 and entered by the Examiner on 12/12/2007.)

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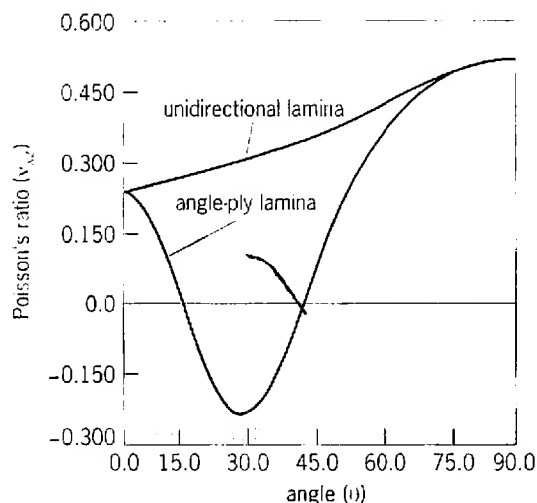


Fig. 5. Through-thickness Poisson's ratios for composite laminate T300/5208.

$\theta = 45^\circ$  where the shear stiffnesses of both the lamina and the laminate are largest, the stiffness of the laminate is more than 3.5 times that of the lamina for the carbon/epoxy under consideration. The results clearly indicate that  $\pm 45^\circ$  fiber orientations are desired in structures requiring high shear stiffness. See SHEAR.

**Coefficients of mutual influence.** For anisotropic materials such as fibrous composites, there are additional important engineering properties that describe material behavior. These properties are called coefficients of mutual influence. They are similar to Poisson's ratios in that they provide an indication of the coupling between normal and shear components of strain. This type of coupling is not present in isotropic materials. One of the coefficients of mutual influence for unidirectional off-axis lamina of two different materials (T300/5208 carbon/epoxy and SCS6/Ti-15-3, a metal matrix composite) is the ratio of shear strain to axial strain for applied stress in the axial direction. The most significant features of the results are that the coefficient exhibits very large gradients and magnitudes for the carbon/epoxy in the vicinity of  $\theta = \pm 12^\circ$ , and that there is a major difference in maximum values between the two materials. The coefficient of mutual influence can be nearly twice as large as Poisson's ratio. Thus the coupling between axial and shear response can be twice as large as the coupling between axial and transverse response for unidirectional lamina. The effective coefficient of mutual influence is zero for angle-ply laminates because the  $+\theta$  and  $-\theta$  fiber orientations have the effect of offsetting one another.

**Laminate design.** A wide variety of effective material properties can be obtained with one type of fibrous composite simply through changes in the stacking arrangement (layer thicknesses and fiber orientations of the individual layers) of the laminate. For example, changing the type of composite provides even more variety in the properties. Thus, material properties of the laminate can be tailored. This is a very impor-

tant feature of fibrous composites because the material can be designed to have specific material properties.

**Coefficient of thermal expansion.** The wide variety of coefficients of thermal expansion are possible through changes in the stacking arrangement of a given carbon/epoxy. The coefficient of thermal expansion is the strain associated with a change in temperature of 1. Most materials have positive coefficients of expansion and thus expand when heated and contract when cooled. The effective axial coefficient of thermal expansion of the carbon/epoxy can be positive, negative, or zero, depending upon the laminate configuration. Laminates with zero coefficient of thermal expansion are particularly important because they do not expand or contract when exposed to a temperature change. Composites with zero (or near zero) coefficient of thermal expansion are therefore good candidates for application in space structures where the temperature change can be 500°F (from  $-250$  to  $+250^\circ\text{F}$ ) [ $278^\circ\text{C}$  (from  $-157$  to  $+121^\circ\text{C}$ )] during an orbit in and out of the Sun's proximity. There are many other applications where thermal expansion is a very important consideration.

Carl T. Herakovich

**Bibliography.** S. B. Dong, K. S. Pister, and R. L. Taylor, On the theory of laminated anisotropic shells and plates, *J. Aerosp. Sci.*, 29:969-975, 1962; C. T. Herakovich, *Mechanics of Fibrous Composites*, John Wiley, New York, 1998; G. Kirchhoff, *J. f. Math. (Crelle)*, Bd. 40, 1850; K. S. Pister and S. B. Dong, Elastic bending of layered plates, *J. Eng. Mech. Div.*, ASCE, EM 1:1-10, October 1959; E. Reissner and Y. Stavsky, Bending and stretching of certain types of heterogeneous anisotropic elastic plates, *J. Appl. Mech.*, ASME, 28:402-408, 1961.

## Composite material

A material system composed of a mixture or combination of two or more macroconstituents that differ in form or material composition and are essentially insoluble in each other. This definition is considered to be too broad by some engineers because it includes many materials that are not usually thought of as composites. For example, in many of the particulate-type composites, such as dispersion-hardened alloys and cermets, the composite structure is microscopic rather than macroscopic. Also, this definition does not draw the line between composite materials and composite structures. However, instead of trying to establish a distinction between materials and structures, it is more useful to make a distinction between mill composites (such as non-metallic laminates, clad metals, and honeycomb) and specialty composites (such as tires, rocket nose cones, and glass-reinforced plastic boats).

### Constituents and Construction

In principle, composites can be constructed of any combination of two or more materials—metallic.

organic, or inorganic; but the constituent forms are more restricted. The matrix is the body constituent, serving to enclose the composite and give it bulk form. Major structural constituents are fibers, particles, laminar or layers, flakes, fillers, and matrices. They determine the internal structure of the composite. Usually, they are the additive phase.

Because the different constituents are intermixed or combined, there is always a contiguous region. It may simply be an interface, that is, the surface forming the common boundary of the constituents. An interface is in some ways analogous to the grain boundaries in monolithic materials. In some cases, however, the contiguous region is a distinct added phase, called an interphase. Examples are the coating on the glass fibers in reinforced plastics and the adhesive that bonds the layers of a laminate together. When such an interphase is present, there are two interfaces, one between the matrix and the interphase and one between the fiber and the interface.

Interfaces are among the most important yet least understood components of a composite material. In particular, there is a lack of understanding of processes occurring at the atomic level of interfaces, and how these processes influence the global material behavior. There is a close relationship between processes that occur on the atomic, microscopic, and macroscopic levels. In fact, knowledge of the sequence of events occurring on these different levels is important in understanding the nature of interfacial phenomena. Interfaces in composites, often

considered as surfaces, are in fact zones of compositional, structural, and property gradients, typically varying in width from a single atom layer to micrometers. Characterization of the mechanical properties of interfacial zones is necessary for understanding mechanical behavior.

**Nature and performance.** Several classification systems for composites have been developed, including classification by (1) basic material combinations, for example, metal-organic or metal-inorganic; (2) bulk-form characteristics, such as matrix systems or laminates; (3) distribution of the constituents, that is, continuous or discontinuous; and (4) function, for example, electrical or structural.

There are five classes under the classification by basic material combinations: (1) fiber composites, composed of fibers with or without a matrix; (2) flake composites, composed of flat flakes with or without a matrix; (3) particulate composites, composed of particles with or without a matrix; (4) filled (or skeletal) composites, composed of a continuous skeletal matrix filled by a second material; and (5) laminar composites, composed of layer or laminar constituents.

There is also a classification based on dimensions. The dimensions of some of the components of composite materials vary widely and overlap the dimensions of the microstructural features of common conventional materials (Fig. 1). They range from extremely small particles or fine whiskers to the large aggregate particles or rods in reinforced concrete.

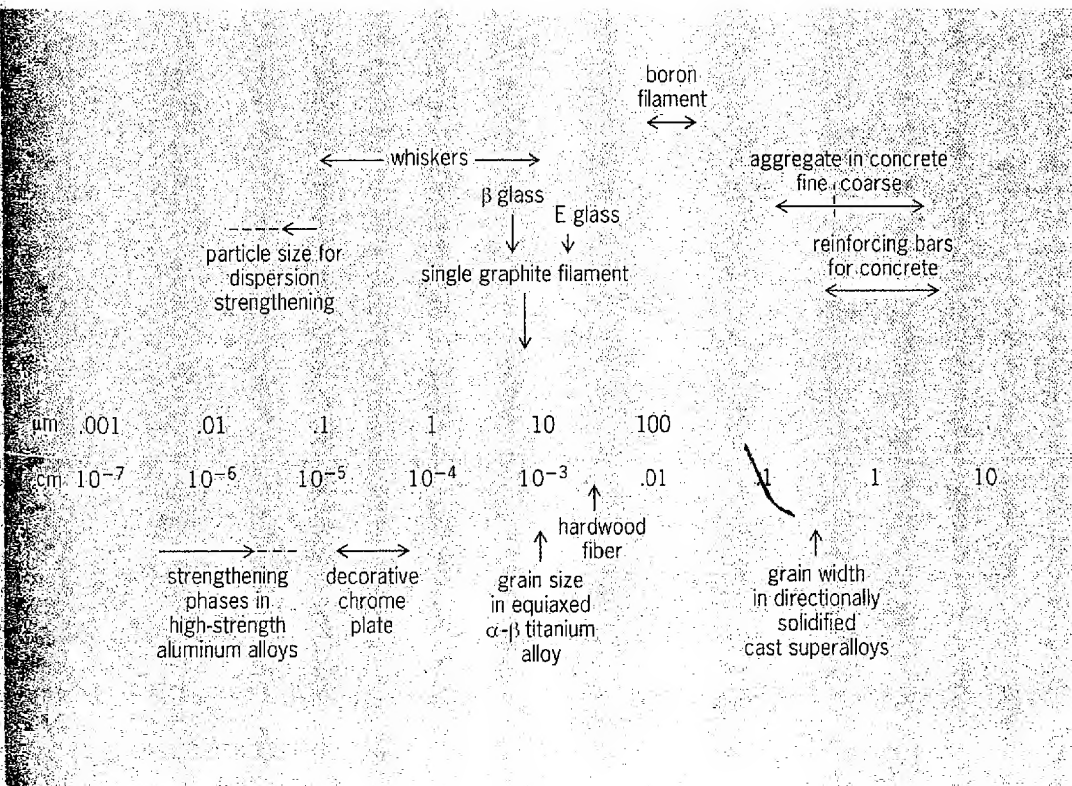


Fig. 1. Dimensional range of microstructural features in composite and conventional materials. Filament and fiber dimensions are diameters. 1 cm = 0.39 in.

See CRYSTAL WHISKERS; REINFORCED CONCRETE.

The behavior and properties of composites are determined by the composition, form and arrangements, and interaction between the constituents. The intrinsic properties of the materials of which the constituents are composed largely determine the general order or range of properties of the composite. Structural and geometrical characteristics—that is, the shape and size of the individual constituents, their structural arrangement and distribution, and the relative amount of each—contribute to overall performance. Of far-reaching importance are the effects produced by the combination and interaction of the constituents. The basic principle is that by using different constituents it is possible to obtain combinations of properties and property values that are different from those of the individual constituents.

A performance index is a property or group of properties that measures the effectiveness of a material in performing a given function. The values of performance indices for a composite differ from those of the constituents.

**Fiber-matrix composites.** Fiber-matrix composites have two constituents and usually a bonding phase as well.

**Fibers.** The performance of a fiber-matrix composite depends on orientation, length, shape, and composition of the fibers; mechanical properties of the matrix; and integrity of the bond between fibers and matrix. Of these, orientation of the fibers is perhaps most important.

Fiber orientation determines the mechanical strength of the composite and the direction of greatest strength. Fiber orientation can be one-dimensional, planar (two-dimensional), or three-dimensional. The one-dimensional type has maximum composite strength and modulus in the direction of the fiber axis. The planar type exhibits different strengths in each direction of fiber orientation; and the three-dimensional type is isotropic but has greatly decreased reinforcing values. The mechanical properties in any one direction are proportional to the amount of fiber by volume oriented in that direction. As fiber orientation becomes more random, the mechanical properties in any one direction become lower.

Fiber length also impacts mechanical properties. Fibers in the matrix can be either continuous or short. Composites made from short fibers, if they could be properly oriented, could have substantially greater strengths than those made from continuous fibers. This is particularly true of whiskers, which have uniform high tensile strengths. Both short and long fibers are also called chopped fibers. Fiber length also has a bearing on the processibility of the composite. In general, continuous fibers are easier to handle but have more design limitations than short fibers.

**Bonding.** Fiber composites are able to withstand higher stresses than their individual constituents because the fibers and matrix interact, resulting in re-

distribution of the stresses. The ability of constituents to exchange stresses depends on the effectiveness of the coupling or bonding between them. Bonding can sometimes be achieved by direct contact of the two phases, but usually a specially treated fiber must be used to ensure a receptive adherent surface. This requirement has led to the development of fiber finishes, known as coupling agents. Both chemical and mechanical bonding interactions occur for coupling agents.

Voids (air pockets) in the matrix are one cause of failure. A fiber passing through the void is not supported by resin. Under load, the fiber may buckle and transfer stress to the resin, which readily cracks. Another cause of early failure is weak or incomplete bonding. The fiber-matrix bond is often in a state of shear when the material is under load. When this bond is broken, the fiber separates from the matrix and leaves discontinuities that may cause failure. Coupling agents can be used to strengthen these bonds against shear forces. See SHEAR.

**Reinforced plastics.** Probably the greatest potential for lightweight high-strength composites is represented by the inorganic fiber-organic-matrix composites, and no composite of this type has proved as successful as glass-fiber-reinforced plastic composites. As a group, glass-fiber-plastic composites have the advantages of good physical properties, including strength, elasticity, impact resistance, and dimensional stability; high strength-to-weight ratio; good electrical properties; resistance to chemical attack and outdoor weathering; and resistance to moderately high temperatures (about 260°C or 500°F).

A critical factor in reinforced plastics is the strength of the bond between the fiber and the polymer matrix; weak bonding causes fiber pullout and delamination of the structure, particularly under adverse environmental conditions. Bonding can be improved by coatings and the use of coupling agents. Glass fibers, for example, are treated with silane ( $\text{SiH}_3$ ) for improved wetting and bonding between the fiber and the matrix.

Generally, the greatest stiffness and strength in reinforced plastics are obtained when the fibers are aligned in the direction of the tension force. Other properties of the composite, such as creep resistance, thermal and electrical conductivity, and thermal expansion, are anisotropic. The transverse properties of such a unidirectionally reinforced structure are much lower than the longitudinal. Seven mechanical and thermal properties are of direct interest in assessing the potential of a new composite: density, modulus, strength, toughness, thermal conductivity, expansion coefficient, and heat capacity; others, such as fracture toughness and thermal diffusivity, are calculated from them.

### Advanced Composites

Advanced composites comprise structural materials that have been developed for high-technology applications, such as airframe structures, for which other

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materials are not sufficiently stiff. In these materials, extremely stiff and strong continuous or discontinuous fibers, whiskers, or small particles are dispersed in the matrix. A number of matrix materials are available, including carbon, ceramics, glasses, metals, and polymers. Advanced composites possess enhanced stiffness and lower density compared to fiber-glass and conventional monolithic materials. While composite strength is primarily a function of the reinforcement, the ability of the matrix to support the fibers or particles and to transfer load to the reinforcement is equally important. Also, the matrix frequently dictates service conditions, for example, the upper temperature limit of the composite.

**Reinforcements.** Continuous filamentary materials that are used as reinforcing constituents in advanced composites are carbonaceous fibers, organic fibers, inorganic fibers, ceramic fibers, and metal wires. Reinforcing inorganic materials are used in the form of discontinuous fibers and whiskers. See STRENGTH OF MATERIALS.

Carbon and graphite fibers offer high modulus and the highest strength of all reinforcing fibers. These fibers are produced in a pyrolysis chamber from three different precursor materials—rayon, polyacrylonitrile (PAN), and pitch. High-modulus carbon fibers are available in an array of yarns and bundles of continuous filaments (tows) with differing moduli, strengths, cross-sectional areas, twists, and plies. See CARBON; GRAPHITE.

Almost any polymer fiber can be used in a composite structure, but the first one with high-enough tensile modulus and strength to be used as a reinforcement in advanced composites was an aramid, or aromatic polyamide, fiber. Aramid fibers have been the predominant organic reinforcing fiber; graphite is a close second. See MANUFACTURED FIBER; POLYMER.

The most important inorganic continuous fibers for reinforcement of advanced composites are boron and silicon carbide, both of which exhibit high stiffness, high strength, and low density. Continuous fibers are made by chemical vapor deposition processes. Other inorganic compounds that provide stiff, strong discontinuous fibers that predominate as reinforcements for metal matrix composites are silicon carbide, aluminum oxide, graphite, silicon nitride, titanium carbide, and carbon carbide. See BORON.

Polycrystalline aluminum oxide ( $Al_2O_3$ ) is a commercial continuous fiber that exhibits high stiffness, high strength, high melting point, and exceptional resistance to corrosive environments. One method to produce the fibers is dry spinning followed by heat treatment.

Whiskers are single crystals that exhibit fibrous characteristics. Compared to continuous or discontinuous polycrystalline fibers, they exhibit exceptionally high strength and stiffness. Silicon carbide whiskers are prepared by chemical processes or by pyrolysis of rice hulls. Whiskers made of aluminum oxide and silicon nitride are also available. Particu-

lates vary widely in size, characteristics, and function; and since particulate composites are usually isotropic, their distribution is usually random rather than controlled. See PYROLYSIS.

**Organic-matrix composites.** In many advanced composites the matrix is organic, but metal matrices are also used. Organic matrix materials are lighter than metals, adhere better to the fibers, and offer more flexibility in shaping and forming. Ceramic matrix composites, carbon-carbon composites, and intermetallic matrix composites have applications where organic or metal matrix systems are unsuitable.

**Materials.** Epoxy resins have been used extensively as the matrix material. However, bismaleimide resins and polyimide resins have been developed to enhance in-service temperatures. Thermoplastic resins, polyetherketone, and polyphenylene sulfide are in limited use.

The continuous reinforcing fibers for organic matrices are available in the forms of monofilaments, multifilament fiber bundles, unidirectional ribbons, roving (slightly twisted fiber), and single-layer and multilayer fabric mats. Frequently, the continuous reinforcing fibers and matrix resins are combined into a nonfinal form known as a prepreg.

**Fabrication.** Many processes are available for the fabrication of organic matrix composites. The first process is contact molding in order to orient the unidirectional layers at discrete angles to one another. Contact molding is a wet method, in which the reinforcement is impregnated with the resin at the time of molding. The simplest method is hand lay-up, whereby the materials are placed and formed in the mold by hand and the squeezing action expels any trapped air and compacts the part.

Molding may also be done by spraying, but these processes are relatively slow and labor costs are high, even though they can be automated. Many types of boats, as well as buckets for power-line servicing equipment, are made by this process.

Another process is vacuum-bag molding, where prepreps are laid in mold to form the desired shape. In this case, the pressure required to form the shape and achieve good bonding is obtained by covering the lay-up with a plastic bag and creating a vacuum. If additional heat and pressure are desired, the entire assembly is put into an autoclave. In order to prevent the resin from sticking to the vacuum bag and to facilitate removal of excess resin, various materials are placed on top of the prepreg sheets. The molds can be made of metal, usually aluminum, but more often are made from the same resin (with reinforcement) as the material to be cured. This eliminates any problem with differential thermal expansion between the mold and the part.

In filament winding, the resin and fibers are combined at the time of curing. Axisymmetric parts, such as pipes and storage tanks, are produced on a rotating mandrel. The reinforcing filament, tape, or roving is wrapped continuously round the form. The reinforcements are impregnated by passing them

through a polymer bath. However, the process can be modified by wrapping the mandrel with prepreg material. The products made by filament winding are very strong because of their highly reinforced structure. For example, filament winding can be used directly over solid-rocket-propellant forms.

Pultrusion is a process used to produce long shapes with constant profiles, such as rods or tubing, similar to extruded metal products. Individual fibers are often combined into a tow, yarns, or roving, which consists of a number of tows or yarns collected into a parallel bundle without twisting (or only slightly so). Filaments can also be arranged in a parallel array called a tape and held together by a binder. Yarns or tows are often processed further by weaving, braiding, and knitting or by forming them into a sheetlike mat consisting of randomly oriented chopped fibers or swirled continuous fibers held together by a binder.

Weaving to produce a fabric is a very effective means of introducing fibers into a composite. There are five commonly used patterns (Fig. 2). Although weaving is usually thought of as a two-dimensional process, three-dimensional weaving is often employed.

Knitting is a process of interlooping chains of tow or yarn. Advantages of this process are that the tow or yarn is not crimped as happens in weaving, and higher mechanical properties are often ob-

served in the reinforced product. Also, knitted fabrics are easy to handle and can be cut without falling apart.

In braiding, layers of helically wound yarn or tow are interlaced in a cylindrical shape, and interlocks can be produced at every intersection of fibers. During the process, a mandrel is fed through the center of a braiding machine at a uniform rate, and the yarn or tow from carriers is braided around the mandrel at a controlled angle. The machine operates like a maypole, the carriers working in pairs to accomplish the over-and-under sequencing. The braiding process is most effective for cylindrical geometries. It is used for missile heat shields, lightweight ducts, fluid-sealing components such as packings and sleeves, and tubes for insulation.

**Carbon-carbon composites.** A carbon-carbon composite is a specialized material made by reinforcing a carbon matrix with continuous carbon fiber. This type of composite has outstanding properties over a wide range of temperatures in both vacuum and inert atmospheres. It will even perform well at elevated temperatures in an oxidizing environment for short times. It has high strength, modulus, and toughness up to 2000°C (3600°F); high thermal conductivity; and a low coefficient of thermal expansion. A material with such properties is excellent for rocket motor nozzles and exit cones, which require high-temperature strength as well as resistance to thermal shock. Carbon-carbon composites are also used for aircraft and other high-performance brake applications that take advantage of the fact that carbon-carbon composites have the highest energy-absorption capability of any known material. If a carbon-carbon composite is exposed to an oxygen-containing atmosphere above 600°C (1100°F) for an appreciable time, it oxidizes, and therefore it must be protected by coatings.

**Metal-matrix composites.** Metal-matrix composites are usually made with alloys of aluminum, magnesium, or titanium; and the reinforcement is typically a ceramic in the form of particulates, platelets, whiskers, or fibers, although other systems may be used. Metal-matrix composites are often classified as discontinuous or continuous, depending on the geometry of the reinforcement. Particulates, platelets, and whiskers are in the discontinuous category, while the continuous category is reserved for fibers and wires. The type of reinforcement is important in the selection of a metal-matrix composite, because it determines virtually every aspect of the product, including mechanical properties, cost, and processing method. The primary methods for processing of discontinuous metal-matrix composites are powder metallurgy, liquid metal infiltration, squeeze or pressure casting, and conventional casting; however, most of these methods do not result in finished parts. Therefore, most discontinuously reinforced metal-matrix composites require secondary processing, which includes conventional wrought metallurgy operations such as extrusion, forging, and rolling; standard and nonstandard machining operations; and joining techniques such as welding and brazing.

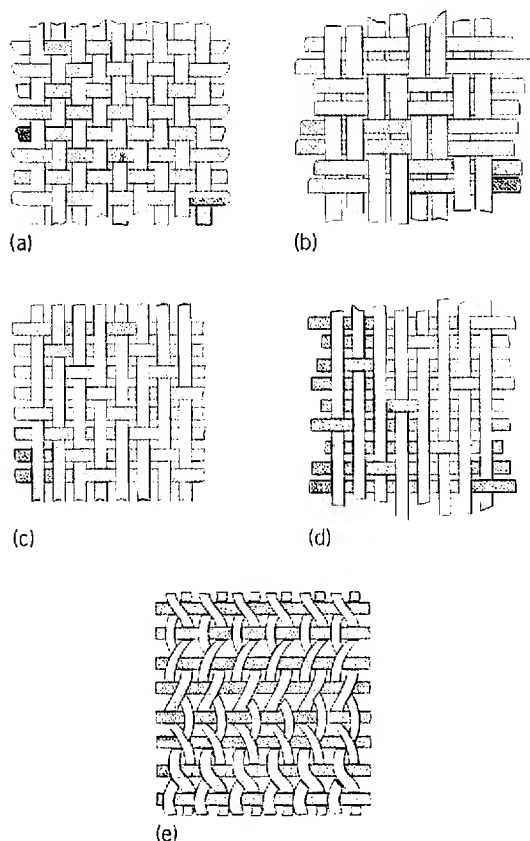


Fig. 2. Common weave patterns: (a) box or plain weave, (b) basket weave, (c) crowfoot, (d) long-shaft, and (e) leno weave.

See BRAZING METALLURGY

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See BRAZING; MACHINING; METAL CASTING; POWDER METALLURGY; WELDING AND CUTTING OF METALS.

Mel M. Schwartz

**Ceramic-matrix composites.** In general, ceramics are brittle engineering materials with limited reliability. Brittleness is connected with the structure and chemical bonding of the main constituents, and reliability is connected with the stochastic character of main phases and defect distribution within the polycrystalline ceramic body. In spite of the generally high strength, hardness, and chemical and shape stability of ceramics, these two negative properties disqualify their wider application in industry. Ceramic-matrix composites are designed as materials with higher fracture resistance (less brittleness), higher reliability, and in particular cases higher strength compared to monolithic ceramics. These attributes are required for high technologies, especially in the aircraft, automotive, engineering, and energy industries. See BRITTLINESS; CERAMICS.

Ceramic composites are materials with at least two constituents, the ceramic-matrix phase and reinforcing-toughening filaments. The filaments cover a wide range of dimensions, from nanoinclusions, through micro-whiskers, to fibers that are several centimeters to a few meters long.

**Ceramic nanocomposites.** These composites have at least one of the main constituents at the nanometer scale (from one to several hundred nanometers). Typical examples of such ceramic nanocomposites are silicon carbide-silicon nitride ( $\text{SiC}/\text{Si}_3\text{N}_4$ ) and silicon carbide-alumina ( $\text{SiC}/\text{Al}_2\text{O}_3$ ). Benefits from the design of these materials are better mechanical properties at room temperature or high temperature, as well as improved electric and magnetic properties. See NANOSTRUCTURE.

Examples of some properties of nanocomposites are as follows: A  $\text{SiC}/\text{Si}_3\text{N}_4$  nanocomposite containing 20 vol % SiC has a bending strength greater than 1 GPa (10000 atm) up to 1400°C (2552°F), and a fracture toughness of 7  $\text{MPa}\cdot\text{m}^{1/2}$ . Silver-ferrite oxide nanocomposite ( $\text{Ag}/\text{Fe}_3\text{O}_4$ ) exhibits a superparamagnetic state at temperatures greater than 100 K (−173°C; −280°F).

Based on distribution of nanograins within the matrix, ceramic nanocomposites can be formally divided into intra type, inter type, intra/inter type, and nano/nano type. The  $\text{SiC}/\text{Si}_3\text{N}_4$  nanocomposite (Fig. 3) can be considered an intra/inter type, because of distribution of SiC grains at grain boundaries as well as within the  $\text{Si}_3\text{N}_4$  grains.

**Whisker/platelet-reinforced composites.** This ceramic composite contains whiskers or platelets. The whiskers are randomly distributed within the composite matrix. Silicon carbide or silicon nitride whiskers are usually embedded in a silicon carbide, silicon nitride, or alumina matrix. Improvement of the mechanical properties of these composites is reached by dissipation of the crack tip energy on a whisker or platelet. Whisker length varies between several micrometers and hundreds of micrometers. A typical parameter that determines a whisker shape is the aspect ratio, or the length-to-thickness ratio. Platelets are sin-

gle crystals of flake shape. Their aspect ratio is the diameter-to-thickness ratio. Despite lower effectiveness of platelets in dissipating crack tip energy compared to the whiskers, their application is forced due to the environmental unacceptability of whiskers. The bending strength of  $\text{Si}_3\text{N}_4/\text{Si}_3\text{N}_4$  ceramics is 0.8–1 GPa (8000–10,000 atm), and fracture toughness is 6  $\text{MPa}\cdot\text{m}^{1/2}$  at room temperature.

**Ceramic fiber-matrix composites.** In principle, these composites are similar to fiber-matrix composites. The difference is in the composition of fibers, the matrices, and the processing routes.

The typical examples of fibers are the silicon carbide or alumina fibers. Fibers are polycrystalline materials with high tensile strength. Silicon carbide fiber tensile strength for Hi-Nicalon-S fiber is greater than 3 GPa (30,000 atm).

Silicon carbide, silicon nitride, and alumina ceramics are typically used as the matrices. Carbon as a constituent of these composites is also used either in the form of fibers or as a matrix.

There are several processes of embedding the continuous fibers into the ceramic matrix: polymer impregnation and pyrolysis, slurry impregnation and hot pressing, and chemical vapor infiltration.

These materials exhibit a high tensile strength when the fibers are oriented in the direction of the tensile force, and a very high work of fracture, which means a high fracture toughness. For example, the tensile strength of a  $\text{SiC}/\text{Si}_3\text{N}_4$  composite is 0.5 GPa (5000 atm), and the fracture toughness is 26.5  $\text{MPa}\cdot\text{m}^{1/2}$ .

**Laminate/layered ceramic composites.** These ceramic composites consist of two or more different ceramic sheets which are repeated several times through the ceramic body. These materials are usually produced by tape casting in order to build the ceramic "green" body, which is densified by hot pressing or gas pressure sintering. The properties of this type of ceramics are highly anisotropic in different directions,

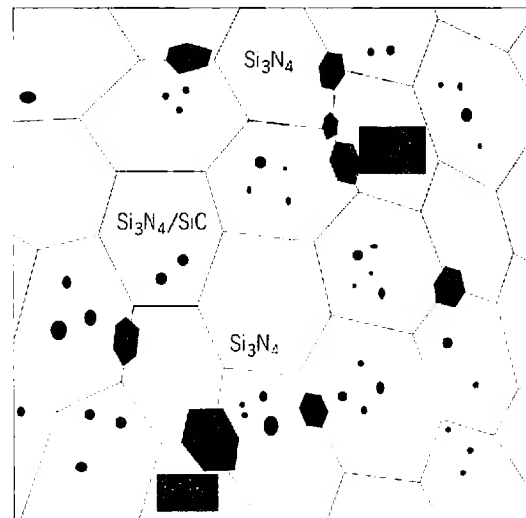


Fig. 3. Schematic of a  $\text{SiC}/\text{Si}_3\text{N}_4$  nanocomposite. This microstructure consists of silicon carbide inclusions within silicon nitride grains, and silicon carbide grains located at the grain boundaries.



parallel and perpendicular to the layer area. The layers can differ by composition or by microstructure. Mechanical properties of silicon nitride-based layered composite are in particular cases exceptional; for example, a bending strength of 1.2 GPa (12,000 atm) and a fracture toughness of 10 MPa·m<sup>1/2</sup> are reported. See SINTERING.

Layered materials offer a possibility to design materials with multifunctions, exhibiting excellent mechanical properties and improved electrical, thermal, or magnetic properties. Pavol Šajgalík

### Applications

The use of fiber-reinforced materials in engineering applications has grown rapidly. Selection of composites rather than monolithic materials is dictated by the choice of properties. The high values of specific stiffness and specific strength may be the determining factor, but in some applications wear resistance or strength retention at elevated temperatures is more important. A composite must be selected by more than one criterion, although one may dominate.

Components fabricated from advanced organic-matrix-fiber-reinforced composites are used extensively on commercial aircraft as well as for military transports, fighters, and bombers. The propulsion system, which includes engines and fuel, makes up a significant fraction of aircraft weight (frequently 50%) and must provide a good thrust-to-weight ratio and efficient fuel consumption. The primary means of improving engine efficiency are to take advantage of the high specific stiffness and strength of composites for weight reduction, especially in rotating components, where material density directly affects both stress levels and critical dynamic characteristics, such as natural frequency and flutter speed.

Composites consisting of resin matrices reinforced with discontinuous glass fibers and continuous-glass-fiber mats are widely used in truck and automobile components bearing light loads, such as interior and exterior panels, pistons for diesel engines, drive shafts, rotors, brakes, leaf springs, wheels, and clutch plates.

The excellent electrical insulation, formability, and low cost of glass-fiber-reinforced plastics have led to their widespread use in electrical and electronic applications ranging from motors and generators to antennas and printed circuit boards.

Composites are also used for leisure and sporting products such as the frames of rackets, fishing rods, skis, golf club shafts, archery bows and arrows, sailboats, racing cars, and bicycles.

Advanced composites are used in a variety of other applications, including cutting tools for machining of superalloys and cast iron and laser mirrors for outer-space applications. They have made it possible to mimic the properties of human bone, leading to development of biocompatible prostheses for bone replacements and joint implants. In engineering, composites are used as replacements for fiber-reinforced

cements and cables for suspension bridges. See MATERIALS SCIENCE AND ENGINEERING. Mel M. Schwartz  
Bibliography. N. P. Cheremisinoff and P. N. Cheremisinoff (eds.), *Handbook of Advanced Materials Testing*, Marcel Dekker, New York, 1995; M. Grayson (ed.), *Encyclopedia of Composite Materials and Components*, John Wiley, New York, 1983; G. Lubin (ed.), *Handbook of Composites*, 1982; K. Niihara, New design concept of structural ceramics: Ceramic nanocomposites, *J. Ceramic Soc. Jap.*, 99:974-982, 1991; T. Richardson, *A Design Guide*, 1987; T. Rienhart, *Engineered Materials Handbook*, vol. 1: *Composites, Metals*, 1987; S. J. Schneider, Jr. (ed.), *Engineered Materials Handbook*, vol. 4: *Ceramics and Glasses*, ASM International, 1991; M. M. Schwartz, *Composite Materials Handbook*, 2d ed., 1992; J. W. Weeton (ed.), *Engineer's Guide to Composite Materials*, 1986.

### Composition board

A wood product in which the grain structure of the original wood is drastically altered. Composition board may be divided into several types. When wood serves as the raw material for chemical processing, the resultant product may be insulation board, hardboard, or other pulp product. When the wood is broken down only by mechanical means, the resultant product is particle board. Because composition board can use waste products of established wood industries and because there is a need to find marketable uses for young trees, manufacture of composition board is one of the most rapidly developing portions of the wood industry. See PAPER.

**Fiberboard.** One form of fiberboard is produced by loading a batch of wood chips into a chamber which is then heated and pressurized by steam. After about 2 min, the 1000-lb/in.<sup>2</sup> (6.9-megapascal) pressure is abruptly released to hydrolyze and fluff the chips into a brown fiber. The fiber is refined, washed, and felted into a mat on a wire conveyor so that some of the water can drain out, and then the mat is cut to length for loading on a screen into a press. At controlled temperature in the press, the lignin rebonds the material while water is driven off as steam through the screen. The finished reconstituted wood product is a hard isotropic board as a consequence of the felted of the fibers and the ligneous bonding, possibly augmented by synthetic adhesive.

Alternatively, a similar board is produced by a continuous process. A screw feed delivers wood chips from a hopper to a steam preheater where the chips partially hydrolyze in the vicinity of 150 lb/in.<sup>2</sup> (0.11 MPa). The hot chips pass between grinding disks to discharge as pulp, which is then formed into sheets essentially as described above. The wood chips may also be processed entirely by grinding. A further variation is to deliver the pulp slurry into a deckle box, in which case most of the water is removed by suction applied below the box before the mat is compressed into the finished sheet.

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**RELATED PROCEEDINGS APPENDIX**

A copy of the prior decision of 09/28/2005 in this application, Appeal No. 200-2658, by the Board of Patent Appeals and Interferences is attached.

The opinion in support of the decision being entered today was *not* written for publication and is *not* binding precedent of the Board.

UNITED STATES PATENT AND TRADEMARK OFFICE

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BEFORE THE BOARD OF PATENT APPEALS  
AND INTERFERENCES

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*Ex parte* M. ASHRAF IMAM,  
BHAKTA B. RATH and TEDDY M. KELLER

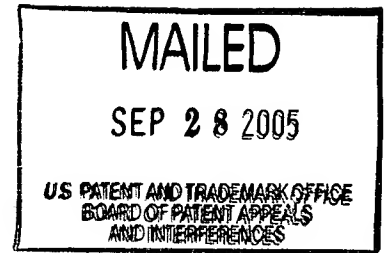
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Appeal No. 2005-2658  
Application 08/845,897

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ON BRIEF

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Before PAK, WARREN and KRATZ, *Administrative Patent Judges*.

WARREN, *Administrative Patent Judge*.

*Decision on Appeal*

This is an appeal under 35 U.S.C. § 134 from the decision of the examiner finally rejecting claims 1 through 4, 7, 11 and 17 through 22. Claims 5, 6, 8 through 10 and 12 through 16 are also of record and have been withdrawn from consideration by the examiner under 37 CFR § 1.142(b).

We have considered the answer mailed April 10, 2001; the supplemental answer mailed September 10, 2003, in response to our remand in Appeal No. 2002-0482 entered on June 26, 2003, in this application; the substitute brief filed February 16, 2001; and the reply brief filed May 15, 2001.

Claim 1 illustrates appellants' invention of an acoustically damping composite article, and is representative of the claims on appeal:<sup>1</sup>

1. An acoustically damping composite article, comprising a non-elastomeric polymeric matrix having therein a metal foam, said metal foam having an open cell structure, said metal foam being impregnated with said polymeric matrix so as to completely penetrate said open cell structure of said foam and fill the cells thereof.

The references relied on by the examiner in the grounds of rejection are:<sup>2</sup>

Tsang et al. (Tsang)	4,605,595	Aug. 12, 1986
Reitz	4,759,000	Jul. 19, 1988

The examiner has advanced the following grounds of rejection on appeal:

claims 1 through 4, 7, 11, 19 and 22 stand rejected under 35 U.S.C. § 102(b) as anticipated by Tsang (answer, pages 3-4);

claims 1 through 4, 7, 11, 19 and 22 stand rejected under 35 U.S.C. § 102(b) as anticipated by or, in the alternative, under 35 U.S.C. § 103(a) as being obvious over Reitz (answer, page 4); and

claims 17, 18, 20 and 21 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over either Tsang or Reitz (answer, pages 4-5);

Appellants state that the appealed claims "stand or fall together" (brief, page 5). Thus, we decide this appeal based on appealed claims 1 and 21 as representative of the appealed claims and the grounds of rejection. 37 CFR § 1.192(c)(7) (2000); *see also* 37 CFR § 41.37(c)(1)(vii) (September 2004).

We affirm the grounds of rejection of appealed claims 1 through 4, 7, 11 and 17 through 22 under §§ 102(b) and 103(a) over Tsang, and reverse the grounds of rejection of these claims based on Reitz. Accordingly, the decision of the examiner is affirmed.

We refer to the answer and supplemental answer and to the substitute brief and reply brief for a complete exposition of the positions advanced by the examiner and appellants.

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<sup>1</sup> The examiner has states that the copy of appealed claim 3 in the appendix to the substitute is in error and has provide a correct copy thereof in the answer (page 3).

<sup>2</sup> The examiner has cited Jarema et al. in the listing of "Prior Art of Record" in the supplemental answer (page 3), and has relied on this patent document to support the grounds of rejection (supplemental answer, page 8) even though this reference was not cited in the statement of any of the grounds of rejection (answer, pages 3-5; supplemental answer, pages 4-5), and indeed, was not cited in the answer. Accordingly, we have not considered Jarema et al. *See In re Hoch*, 428 F.2d 1341, 1342 n.3, 166 USPQ 406, 407 n.3 (CCPA 1970); *compare Ex parte Raske*, 28 USPQ2d 1304, 1304-05 (Bd. Pat. App. & Int. 1993).

*Opinion*

In order to review the examiner's application of prior art to appealed claims 1 and 21, we must interpret these claims by giving the terms thereof the broadest reasonable interpretation in their ordinary usage as they would be understood by one of ordinary skill in the art in light of the written description in the specification, including the drawings, as interpreted by this person, unless another meaning is intended by appellants as established in the written description of the specification, and without reading into the claims any limitation or particular embodiment disclosed in the specification. *See, e.g., In re Morris*, 127 F.3d 1048, 1054-55, 44 USPQ2d 1023, 1027 (Fed. Cir. 1997); *In re Zletz*, 893 F.2d 319, 321-22, 13 USPQ2d 1320, 1322 (Fed. Cir. 1989). We determine that the plain language of independent claim 1 encompasses a composite article that comprises at least any non-elastomeric polymeric matrix and any metal foam having an open cell structure, wherein the non-elastomeric polymeric matrix has therein the metal foam and completely fills the cells thereof. We determine that the preambular language "[a]n acoustically damping composite article" when considered in the context of the claimed invention as a whole, including consideration thereof in light of the written description in appellants' specification, must be given weight as a claim limitation which characterizes the claimed method in order to give meaning to the claim and properly define the invention. *See generally In re Fritch*, 972 F.2d 1260, 1262, 23 USPQ2d 1780, 1781 (Fed. Cir. 1992) (citing *Perkin-Elmer Corp. v. Computervision Corp.*, 732 F.2d 888, 896, 221 USPQ 669, 675 (Fed. Cir.), cert. denied, 469 U.S. 857[, 225 USPQ 792] (1984)); *Corning Glass Works v. Sumitomo Elec. U.S.A., Inc.*, 868 F.2d 1251, 1257, 9 USPQ2d 1962, 1966 (Fed. Cir. 1989), *In re Stencel*, 828 F.2d 751, 754-55, 4 USPQ2d 1071, 1073 (Fed. Cir. 1987). Thus, the preambular language limits the materials for the non-elastomeric polymeric matrix and/or the metal foam to those capable of imparting acoustically damping properties to the composite article at least to some extent, however small.

We point out here that the open-ended transitional term "comprising" opens claim 1 to include acoustically damping composite articles that contains *any* manner and amount of materials and structure in addition to the two ingredients specified in the claim. *See generally, Exxon Chem. Pats., Inc. v. Lubrizol Corp.*, 64 F.3d 1553, 1555, 35 USPQ2d 1801, 1802 (Fed.

Cir. 1995) (“The claimed composition is defined as comprising - meaning containing at least - five specific ingredients.”); *In re Baxter*, 656 F.2d 679, 686-87, 210 USPQ 795, 802-03 (CCPA 1981) (“As long as one of the monomers in the reaction is propylene, any other monomer may be present, because the term ‘comprises’ permits the *inclusion* of other steps, elements, or materials.”). We note in this respect, that appellants state in the written description in the specification that the non-elastomeric polymeric matrix “may include any manner of catalysts, curing agents, or additives desired” (page 8). We will not read into the appealed claims a limitation that any additional ingredient in the polymeric matrix is limited to additives involved with curing the polymer based on this disclosure as urged by appellants (e.g., substitute brief, page 6, and reply brief, page 3), because we find no basis in the claim language or in the written description in the specification on which to do so. *See, Morris*, 127 F.3d at 1054-55, 44 USPQ2d at 1027; *Zletz*, 893 F.2d at 321-22, 13 USPQ2d at 1322.

We determine that appealed independent claim 21 comprises at least *any* polymeric matrix and any metal foam having an open cell structure, wherein the polymeric matrix has therein the metal foam and completely fills the cells thereof, and wherein the thickness of the metal foam falls within the range of at least 3 times the average diameter of said cells. We interpret the preamble language “[a]n acoustically damping composite article” and the open-ended transitional term “comprising” in the same manner as we set forth above with respect to appealed claim 1. Appealed claim 21 differs from appealed claim 1 in that the polymeric matrix is not limited to non-elastomeric polymeric matrices, and in the specified thickness of the metal foam.

We have carefully reviewed the record on this appeal and based thereon find ourselves in agreement with the supported finding advanced by the examiner that as a matter of fact, *prima facie*, appealed claim 1 is anticipated by Tsang (answer, pages 3-4 and pages 5-6; supplemental answer, pages 4 and 6-7). Accordingly, we again evaluate all of the evidence of anticipation and non-anticipation based on the record as a whole, giving due consideration to the weight of appellant’s arguments in the substitute brief and reply brief. *See generally, In re Spada*, 911 F.2d 705, 707 n.3, 15 USPQ2d 1655, 1657 n.3. (Fed. Cir. 1990).

We find that Tsang discloses composite articles comprising open metal foams having an average pore, that is, cell, size of about 0.05 cm, in which the cells of the metal foam are filled with a mixture of epoxy resin, curing agent fillers and friction modifiers and cured (e.g., col. 4, ll. 6-35). Appellants submit that claim 1 requires that the metal foam cells are filled only with polymer and thus, would exclude the presence of filler and friction modifiers (substitute brief, pages 5-6; reply brief, pages 2-4). We disagree. We interpreted claim 1 above to encompass any non-elastomeric polymeric matrices, wherein the matrices can contain any manner of additional materials by reason of the transitional term “comprising.” Thus, claim 1 encompasses composite articles wherein the metal foam cells are filled with epoxy matrices, a non-elastomeric matrices, encompassing filler and friction modifiers,” and accordingly encompasses the structure of the cured composite articles disclosed by Tsang. The argument that the claimed invention “teaches away” from Tsang (substitute brief, page 6) is not an argument that addresses the issue of anticipation. *See Celeritas Technologies Ltd. V. Rockwell International Corp.*, 150 F.3d 1354, 1361, 47 USPQ2d 1516, 1522 (Fed. Cir. 1998) (“[T]he question whether a reference ‘teaches away’ from the invention is inapplicable to an anticipation analysis.”).

The only limitation of appealed claim 1 that is not expressly disclosed by Tsang for the composite articles thereof relied on by the examiner is the requirement that the article must be acoustically damping at least to some extent, however small. However, we find as a matter of fact that it reasonably appears that the composite article comprised of metal foam and the non-elastomeric epoxy would necessarily inherently have the property of acoustically damping at least to some extent even in view of the filler and friction modifiers, as indeed, the same aluminum metal foam and epoxy matrix are disclosed and claimed (e.g., appealed claims 2 and 3) by appellants in this respect. Accordingly, because it reasonably appears that the composite articles of Tsang relied on by the examiner are identical to the claimed composite articles encompassed by appealed claim 1, the burden has shifted to appellants to patentably distinguish the claimed composite articles from those of Tsang by the submission of persuasive argument and/or object evidence. On this record, appellants have not done so in either respect. *See, e.g., In re King*, 801 F.2d 1324, 1326-28, 231 USPQ 136, 138-39 (Fed. Cir. 1986); *In re Best*, 562 F.2d 1252, 1254-56, 195 USPQ 430, 432-34 (CCPA 1977); *In re Skoner*, 517 F.2d 947,

950-51, 186 USPQ 80, 82-83 (CCPA 1975) (“Appellants have chosen to describe their invention in terms of certain physical characteristics . . . . Merely choosing to describe their invention in this manner does not render patentable their method which is clearly obvious in view of [the reference]. [Citation omitted.]”); *cf. Spada*, 911 F.2d at 708-09, 15 USPQ2d at 1657-58 (“The Board held that the compositions claimed by Spada ‘appear to be identical’ to those described by Smith. While Spada criticizes the usage of the word ‘appear,’ we think that it was reasonable for the PTO to infer that the polymerization by both Smith and Spada of identical monomers, employing the same or similar polymerization techniques, would produce polymers having the identical composition.”).

Thus, on this record, as a matter of fact, Tsang satisfies each and every element of the claimed invention, arranged as required by the claim, either expressly or under the principles of inherency, in a manner sufficient to have placed a person of ordinary skill in the art in possession thereof. *See generally, Spada*, 911 F.2d at 708, 15 USPQ2d at 1657.

Accordingly, based on our consideration of the totality of the record before us, we have weighed the evidence of anticipation found in Tsang with appellants’ countervailing evidence of and argument for no anticipation in fact and find that the claimed invention encompassed by appealed claims 1 through 4, 7, 11, 19 and 22 are anticipated as a matter of fact under 35 U.S.C. § 102(b).

Turning now to the ground of rejection of appealed claim 21 under 35 U.S.C. § 103(a) insofar as it is based on Tsang, appellants’ only argument is that Tsang “has no disclosure with regard to acoustic damping” (reply brief, page 7; see substitute brief, page 9). We disagree because, as we found above, the composite articles of Tsang comprised of metal foam and the non-elastomeric epoxy would reasonably appear to have the property of acoustically damping at least to some extent, as indeed, the same aluminum metal foam and epoxy matrix are disclosed and claimed. Accordingly, because it reasonably appears that the composite articles of Tsang relied on by the examiner are identical or substantially identical to the claimed composite articles encompassed by appealed claim 21, the burden has shifted to appellants to patentably distinguish the claimed composite articles from those of Tsang by the submission of persuasive argument and/or object evidence even though this rejection is based on § 103(a). On this record, appellants

have not done so in either respect. *See, e.g., Best*, 562 F.2d at 1254-56, 195 USPQ at 432-34; *Skoner*, 517 F.2d at 950-51, 186 USPQ at 82-83; *cf. Spada*, 911 F.2d at 708-09, 15 USPQ2d at 1657-58.

Accordingly, based on our consideration of the totality of the record before us, we have weighed the evidence of obviousness found in Tsang with appellants' countervailing evidence of and argument for nonobviousness and conclude that the claimed invention encompassed by appealed claims 17, 18, 20 and 21 would have been obvious as a matter of law under 35 U.S.C. § 103(a).

We find that the dispositive issue with respect to whether the composite article disclosed at col. 9, l. 66, to col. 10, l. 12, of Reitz anticipates appealed claim 1 under § 102(b) and renders obvious appealed claims 1<sup>3</sup> and 21 under 35 U.S.C. § 103(a), involves the recitation with respect to the composite article of aluminum-nickel foam and cured GE silicone rubber RTV-11 and RTV-28 which is permitted to cure or harden: "Housing sheet is an acoustic window. It is not, in the present embodiment an acoustically absorptive material such as the RTV silicone rubber materials as taught in U.S. Pat. No. 4,528,652" (col. 10, ll. 2-6). Appellants point out that the appealed claims require that the claimed composite article must be acoustically absorptive and the composite article of Reitz is disclosed to have hardened silicone rubber and function as an acoustic window (substitute brief, page 8). The examiner has given no weight to this disclosure of Reitz on the basis that the preamble language of appealed claims 1 and 21 is not entitled to patentable weight (supplemental answer, page 8) and otherwise finds the disclosure of Reitz not germane to the issue (answer, page 6).

We interpreted the preamble language of appealed claims 1 and 21 as limiting the acoustically damping composite articles above. On this record, we cannot find that, as a matter of fact, the composite article so disclosed by Reitz would reasonably be expected to exhibit the property of acoustically damping to any extent, however small. On this basis, we conclude that the examiner has not in fact established a *prima facie* case of anticipation under 35 U.S.C.

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<sup>3</sup> The alternative grounds of rejection under §§ 102(b) and 103(a) require separate consideration under each statutory provision. *See generally, Spada*, 911 F.2d at 707 n.3, 15 USPQ2d at 1657 n.3.



§ 102(b) over the reference, and because the ground of rejection under 35 U.S.C. § 103(a) rests on the same factual foundation, we likewise conclude that the examiner has not established a *prima case* of obviousness over the reference under this statutory provision.


Accordingly, we reverse the grounds of rejection of appealed claims 1 through 4, 7, 11 and 17 through 22 over Reitz.

The examiner's decision is affirmed.

No time period for taking any subsequent action in connection with this appeal may be extended under 37 CFR § 1.136(a)(1)(iv) (September 2004).

*AFFIRMED*

  
CHUNG R. PAK  
Administrative Patent Judge

  
CHARLES F. WARREN  
Administrative Patent Judge

*Peter F. Kratz*  
PETER F. KRATZ  
Administrative Patent Judge

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